SENSOR CONTROLLED SAMPLING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

This invention relates to liquid sampling apparatus and an associated method of sampling liquid, and more particularly to improved sampling apparatus of the type which employs a positive displacement pump for procuring the desired liquid samples. Even more particularly this invention relates to the apparatus of the type described which has improved means for sensing and controlling the quantity of the sample supplied by the pump.

Modern day concern with environmental conservation has resulted in legislation requiring careful monitoring of wastewater effluent. This task requires the use of rather sophisticated sampling apparatus for repeatedly collecting consistently accurate samples of fluid waste or industrial process fluids. (See for example, the sampling apparatus disclosed in U.S. Pat. Nos. 3,838,719, 3,927,701 and 4,022,059.)

Heretofore three basic means generally have been employed for controlling the volume or amounts of respective samples. The first could be defined as a timed pump operation in which the pump is turned on for a predetermined period of time proportionate to the volume of the sample which is desired. The weakness of this method is that the volume is affected by changes in the vertical lift of the sample, the motor speed, which may vary due to any changes in power supply, and the ambient temperature in which the motor is operating. Another weakness of this method is that the time during which the motor must operate in order to produce the desired sample is determined empirically through trial and error.

A second method often employed has utilized a sensing device which specifically counts and calculates the revolutions of the pumps associated motor shaft or armature; and assuming that a certain amount of fluid is pumped per revolution of the motor shaft, then the desired volume of the fluid can be designated in terms of the rotations of the motor shaft. Although, theoretically, this obviates any error which might result because of unexpected changes in the speed of the motor, there nevertheless is still a considerable margin of error involved when the vertical lift changes during the period of sampling, as is often the case. This method also does not compensate for variations in the lengths of the sample tubing used, or for any accidental plugging or fouling of the line which might reduce the actual volume of fluid pumped per revolution of the motor. Furthermore this system involves the use of moving parts, and is therefore rather prone to failure.

A third method of sample collection which has been utilized comprises a so-called sample collection chamber in which a vacuum is generated to draw a sample into the chamber, which is thereafter dumped. (See for example, the above-noted U.S. Pat. No. 4,022,059.) Although this vacuum system addresses the lift and accuracy question by requiring that the chamber be filled to a certain level before being dumped, nevertheless the construction and operation of this type of apparatus is very expensive and is a rather high in power consumption, which therefore reduces its utility in connection with portable sampling applications. Also, this type of vacuum system is prone to failure because of frequent leaks, which are aggravated each time the equipment is disassembled for periodic cleaning, as is required for equipment of this type.

It is an object of this invention, therefore, to provide new and improved sampling apparatus of the type described which is substantially more reliable, accurate and inexpensive to manufacture than prior such apparatus. In this connection it is an object of this invention also to provide improved means for sensing the actual quantity of fluid delivered to, or discharged from, and associated pump during each sampling operation.

Another object of this invention is to provide an improved method of sampling liquids, and which method is substantially more accurate in measuring the volume of the sample, and which is particularly suited for use with a microprocessor that controls repeated and accurate sampling operations.

A further object of this invention is to provide a novel, non-contacting, non-obstructing sensing means for sensing the presence of a liquid sample in the tubing which is associated with the inlet of the sampling pump of this apparatus.

Additional objects will be apparent from the specification, the appended claims, and the accompanying drawings.

SUMMARY OF THE INVENTION

The apparatus includes an elongate, preferably flexible tube, which is disposed to be inserted at one end into the supply of liquid or fluid which is to be sampled, and the other end of which is connected through a conventional, reversible peristaltic, positive displacement roller pump to the container which is to receive the sample. Adjacent to the tubing at the inlet to the pump is a special noncontacting fluid sensor of the capacitive or ultrasonic type, which produces and electrical signal in response to the presence of fluid in the tube at that particular point. The output signal of the fluid sensor is fed to a microprocessor and real time clock along with data indicating (1) the desired sample aliquot volume, (2) the internal volume of the tube from the fluid supply to the sensing point, and (3) the internal volume of the tubing from the sensing point to the collector. This latter information (2 and 3) can be readily determined when the inner diameter and length of the tubing are known, and in many cases will constitute fixed values for all sampling. Hence the volume of liquid required to fill per linear foot of the tubing also can be determined in advance of sampling. The overall length of the tubing which is employed to select the sample may differ depending upon the locus of the subject matter being sampled, but whenever this overall length is changed, of course, the corresponding input data to the microprocessor must also be changed. Similarly, the desired volume of the sample may likewise be changed at the microprocessor input as desired.

Accordingly, assuming that the three above-noted data (1), (2) and (3) are supplied to the processor along with the signal from the sensor, it is possible for the processor and its associated program immediately to determine a particular time/volume relationship, so that when the operation is initiated the processor will, under the control of the signal from the sensor, operate the associated peristaltic pump repeatedly in cycles. During each cycle the pump is reversed to purge the tubing, operated in a forward direction until liquid appears at the sensor, is again reversed to purge the tubing, and finally is operated in a forward direction for an interval